

PATENT COOPERATION TREATY

From the
INTERNATIONAL SEARCHING AUTHORITY

REC'D 15 FEB 2006

PCT WFO PCT

To:

see form PCT/ISA/220

WRITTEN OPINION OF THE
INTERNATIONAL SEARCHING AUTHORITY
(PCT Rule 43bis.1)

Date of mailing
(day/month/year) see form PCT/ISA/210 (second sheet)

Applicant's or agent's file reference
see form PCT/ISA/220

FOR FURTHER ACTION
See paragraph 2 below

International application No.
PCT/CA2004/000943

International filing date (day/month/year)
25.06.2004

Priority date (day/month/year)
27.06.2003

International Patent Classification (IPC) or both national classification and IPC
H01M8/16, H01M8/18

Applicant
THE UNIVERSITY OF WESTERN ONTARIO

1. This opinion contains indications relating to the following items:

- ☒ Box No. I Basis of the opinion
- ☐ Box No. II Priority
- ☐ Box No. III Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
- ☒ Box No. IV Lack of unity of invention
- ☒ Box No. V Reasoned statement under Rule 43bis.1 (a)(i) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement
- ☐ Box No. VI Certain documents cited
- ☐ Box No. VII Certain defects in the international application
- ☒ Box No. VIII Certain observations on the international application

2. **FURTHER ACTION**

If a demand for international preliminary examination is made, this opinion will usually be considered to be a written opinion of the International Preliminary Examining Authority ("IPEA"). However, this does not apply where the applicant chooses an Authority other than this one to be the IPEA and the chosen IPEA has notified the International Bureau under Rule 66.1bis(b) that written opinions of this International Searching Authority will not be so considered.

If this opinion is, as provided above, considered to be a written opinion of the IPEA, the applicant is invited to submit to the IPEA a written reply together, where appropriate, with amendments, before the expiration of three months from the date of mailing of Form PCT/ISA/220 or before the expiration of 22 months from the priority date, whichever expires later.

For further options, see Form PCT/ISA/220.

3. For further details, see notes to Form PCT/ISA/220.

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**WRITTEN OPINION OF THE
INTERNATIONAL SEARCHING AUTHORITY**

International application No.
PCT/CA2004/000943

Box No. I Basis of the opinion

1. With regard to the **language**, this opinion has been established on the basis of the international application in the language in which it was filed, unless otherwise indicated under this item.
 - ☐ This opinion has been established on the basis of a translation from the original language into the following language , which is the language of a translation furnished for the purposes of international search (under Rules 12.3 and 23.1(b)).
2. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application and necessary to the claimed invention, this opinion has been established on the basis of:
 - a. type of material:
 - ☐ a sequence listing
 - ☐ table(s) related to the sequence listing
 - b. format of material:
 - ☐ in written format
 - ☐ in computer readable form
 - c. time of filing/furnishing:
 - ☐ contained in the international application as filed.
 - ☐ filed together with the international application in computer readable form.
 - ☐ furnished subsequently to this Authority for the purposes of search.
3. ☐ In addition, in the case that more than one version or copy of a sequence listing and/or table relating thereto has been filed or furnished, the required statements that the information in the subsequent or additional copies is identical to that in the application as filed or does not go beyond the application as filed, as appropriate, were furnished.
4. Additional comments:

WRITTEN OPINION OF THE
INTERNATIONAL SEARCHING AUTHORITY

International application No.
PCT/CA2004/000943

Box No. IV Lack of unity of invention

1. ☒ In response to the invitation (Form PCT/ISA/206) to pay additional fees, the applicant has:
- ☒ paid additional fees.
 - ☐ paid additional fees under protest.
 - ☐ not paid additional fees.
2. ☐ This Authority found that the requirement of unity of invention is not complied with and chose not to invite the applicant to pay additional fees.
3. This Authority considers that the requirement of unity of invention in accordance with Rule 13.1, 13.2 and 13.3 is
- ☐ complied with.
 - ☒ not complied with for the following reasons:
see separate sheet
4. Consequently, this report has been established in respect of the following parts of the international application:
- ☒ all parts.
 - ☐ the parts relating to claims Nos.

Box No. V Reasoned statement under Rule 43bis.1(a)(i) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Statement

Novelty (N)	Yes: Claims	2-5,8,9,17-19,21,22,26,31,32,35,36-60,65,66,69
	No: Claims	1,6,7,10-16,20,23-25,27-30,33,34,61-64,67,68
Inventive step (IS)	Yes: Claims	8,9,31,32,48,49,54,59,60,65,66
	No: Claims	1-7,10-30,33-47,50-53,55-58,61-64,67-69
Industrial applicability (IA)	Yes: Claims	1-69
	No: Claims	

2. Citations and explanations

see separate sheet

Box No. VIII Certain observations on the international application

The following observations on the clarity of the claims, description, and drawings or on the question whether the claims are fully supported by the description, are made:

see separate sheet

Re Item IV.

The separate groups of inventions are:

1) claims 1-19,36-69

A bio-fuel cell system and a method of generating electricity with this system, wherein the bio-fuel cell system comprises chemolithotrophic microorganisms that oxidize a member of a redox couple, that is Fe(II)/Fe(III), in the presence of oxygen.

2) claims 20-35

A bio-fuel cell system and a method of generating electricity with this system, wherein the bio-fuel cell system comprises chemolithotrophic microorganisms that oxidize a member of a redox couple in the presence of oxygen in an aqueous solution that contains substantially no iron.

They are not so linked as to form a single general inventive concept (Rule 13.1 PCT) for the following reasons:

The common technical feature of all claims is a bio-fuel cell systems comprising chemolithotrophic microorganisms for the oxidation of a member of a redox couple. Since this common technical feature is already known, redox couples comprising the Fe(II)/Fe(III)-system represent another group of inventions than iron free systems.

Re Item V.

1 Reference is made to the following documents:

- D1 : PATENT ABSTRACTS OF JAPAN vol. 012, no. 130 (E-603), 21 April 1988 (1988-04-21) & JP 62 256382 A (HIDEO TSUNODA), 9 November 1987 (1987-11-09)
- D2 : US 6 495 023 B1 (ZEIKUS GREGORY J ET AL) 17 December 2002 (2002-12-17)

D4: WO 01/04061 A (KOREA INSTITUTE OF SCIENCE AND TECHNOLOGY; KIM, BYUNGHONG; CHANG, INSE) 18 January 2001 (2001-01-18)

2 NOVELTY (Art. 33(2) PCT)

2.1 The present application does not meet the criteria of Article 33(1) PCT, because the subject-matter of independent claims 1 and 62 is not new in the sense of Article 33(2) PCT.

Document D1 discloses (the references in parentheses applying to this document):
A bio-fuel cell system comprising:

- a fuel cell including a cathode compartment containing an aqueous solution with ferric ions being reduced at the cathode electrode and an anode compartment with a fuel having a hydrogen constituent that is oxidized at the anode electrode
- a bioreactor containing chemolithotrophic microorganisms; oxygen and carbon dioxide are fed into the bioreactor, the bioreactor being in flow communication with the cathode compartment so that the aqueous solution containing ferrous ions and protons is transported from the cathode to the bioreactor where the ferrous ions are oxidized by the microorganisms to ferric ions in an aerobic oxidation reaction and a method of generating electricity with said bio-fuel cell system (abstract).

2.2 The present application does not meet the criteria of Article 33(1) PCT, because the subject-matter of independent claim 20 is not new in the sense of Article 33(2) PCT. Document D4 discloses (the references in parentheses applying to this document):

- a bio-fuel cell comprising a cathode compartment, a pump for pumping air into the cathode compartment; an anode compartment with a fuel having a hydrogen constituent being pumped into said anode compartment, said compartments being separated from each other by a membrane permeable to protons; a reaction wherein protons (H^+), formed by the oxidation of the fuel cross the membrane into the cathode compartment; and chemolithotrophic microorganisms immobilized on the cathode electrode, an aqueous solution containing substantially no iron, coating said chemolithotrophic microorganisms for maintaining a suitable humidity of the microbial cells, wherein a reaction at the

cathode electrode is biological reduction of oxygen at the cathode electrode in a reaction given by $O_2 + 4H^+ + 4e^- = 2H_2O$, wherein electrons in that reaction are obtained by transfer from the cathode electrode to the attached microbial cells, wherein electrical power is obtained by making electrical connection between a load and the anode and cathode electrodes (page 1, lines 5-11; page 5, lines 19-21; page 6, lines 4-8; page 6, line 30 - page 7, line 4; claims 1,4).

- 2.3 Dependent claims 6,7,10-16,20,23-25,27-30,33,34,61-64,67 and 68 do not contain any features which, in combination with the features of any claim to which they refer, meet the requirements of the PCT in respect of novelty (Article 33(2) PCT).

3 INVENTIVE STEP (Art. 33(3) PCT)

- 3.1 The present application does not meet the criteria of Article 33(1) PCT, because the subject matter of independent claims 36 and 53 does not involve an inventive step in the sense of Article 33(3)PCT.

- 3.2 Document D1, which is considered to represent the most relevant state of the art to the subject matter of independent claims 36 and 53, discloses (the references in parentheses applying to this document):

—A bio-fuel cell system comprising:

- a fuel cell including a cathode compartment containing an aqueous solution with ferric ions being reduced at the cathode electrode and an anode compartment with a fuel having a hydrogen constituent that is oxidized at the anode electrode
- a bioreactor containing chemolithotrophic microorganisms; oxygen and carbon dioxide are fed into the bioreactor, the bioreactor being in flow communication with the cathode compartment so that the aqueous solution containing ferrous ions and protons is transported from the cathode to the bioreactor where the ferrous ions are oxidized by the microorganisms to ferric ions in an aerobic oxidation reaction (abstract).

- 3.3 The subject-matter of independent claims 36 and 53 differs from the disclosure of D1 in that :

- the chemolithotrophic microorganisms are immobilized at the cathode electrode.
- 3.3.1 The technical effect is the oxidation of the ferrous ions in the cathode compartment
- 3.3.2 The problem to be solved by the present invention may therefore be regarded as saving an external reactor for the oxidation of the ferrous ions.
- 3.3.3 The feature of microorganisms immobilized at the cathode electrode is described in document D2 (column 8, lines 43-61; figure 1) as providing the same advantages as in the present application. The skilled person would therefore regard it as a normal option to include this feature in the bio-fuel cell system described in document D1 in order to solve the problem posed.
- 3.3.4 Therefore the features disclosed in D1 and D2 would be combined by the skilled person, without exercise of any inventive skills in order to solve the problem posed. The proposed solution in independent claims 36 and 53 thus cannot be considered inventive (Article 33(3) PCT).
- 3.4 Dependent claims 2-5, 17-19, 21, 22, 26, 35, 37-47, 50-52, 54-58 and 69 do not contain any features which, in combination with the features of any claim to which they refer, meet the requirements of the PCT in respect of inventive step (Article 33(3) PCT).
- 3.5 The combination of the features of dependent claims 8, 9, 31, 32, 48, 49, 59, 60, 65 and 66 are neither known from, nor rendered obvious by, the available prior art. The reasons are as follows:
 - the use of chemolithotrophic microorganisms from the group consisting of Acidithiobacillus ferrooxidans, Leptospirillum ferrooxidans, Acidimicrobium, Alicyclobacillus and Sulfobacillus in bio-fuel cell systems is neither known from the prior art cited nor would it be obvious to a person skilled in the art to use this microorganisms in bio-fuel cells.

Re Item VIII.

4 CLARITY (Art. 6 PCT)

- 4.1 In claim 31 Acidithiobacillus ferrooxidans and in claim 32 Leptospirillum ferrooxidans and Acidimicrobium (ferrooxidans?) are mentioned. Since the aqueous solution

contains substantially no iron it is not clear how the metabolism of this microorganisms could work in this environment.

- 4.2 Claim 24 is characterised as being dependent on claim 23. Since the fluid containing oxygen is a gas in claim 23 but an aqueous solution in claim 24, claim 24 cannot be dependent on claim 23.
- 4.3 Claim 33 is characterised as being dependent on claim 33.